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UNITED STATES PUBLIC HEALTH SERVICE
RUPERT BLUE, SURGEON GENERAL

TYPHOID FEVER

A REPORT OF A WATER-BORNE OUTBREAK IN DECATUR AND NEW DECATUR, ALA.

BY

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TYPHOID FEVER.

Realizing that there was a considerable prevalence of typhoid fever in Decatur and New Decatur, Ala., the mayors of the two cities, through their Representative in Congress at Washington, requested the Surgeon General of the United States Public Health Service to detail an officer to study the causes of the alleged epidemic and to make such recommendations as appeared necessary for its control. With the approval and cooperation of the local and State health authorities, the writer was accordingly instructed to proceed to Decatur and to take with him, from the laboratory of the Ohio River Investigation station at Cincinnati, equipment sufficient for such laboratory studies as might seem pertinent.

Upon arriving at Decatur February 14, a preliminary survey of the situation was immediately undertaken with the cooperation of the bacteriologist and sanitary engineer of the State board of health, who had arrived the preceding day. After a thorough canvass of all the physicians, reports were received of 27 cases of suspected typhoid fever. In order to establish the identity of the disease in these cases, visits were then made to the bedsides and the diagnosis of typhoid fever was confirmed, both by clinical signs and symptoms and by agglutination tests, the results of which were later reported from the State laboratory.

Suspecting that the public water supply was responsible for the outbreak, the local authorities had, on February 11, advised the boiling of all water used. The water company, upon recommendation of Mr. E. M. Duncan, city bacteriologist of Birmingham, installed February 14, a temporary apparatus for the disinfection of the filtered water with hypochlorite of lime.

A number of suspected cases were being reported daily, and in order to more thoroughly arouse public interest in the gravity of the situation public meetings were held in both cities, and the value of careful and thorough bedside prophylaxis and complete disinfection of all discharges in cases of typhoid fever in the prevention of secondary cases was emphasized. Lantern slides were exhibited to point out the more important phases in the transmission and spread of the disease.

GENERAL DESCRIPTION OF THE DECATURS.

As shown by the accompanying map, Decatur and New Decatur form practically one community, covering an area of about four square miles, located in Morgan County on the southern bank of the Tennessee River in northern Alabama. They are situated on a rather level plateau about 530 feet above sea level, in the midst of an excellent agricultural section with good facilities for manufacturing purposes. Decatur was incorporated in 1826 and New Decatur was laid out in 1886.

The total population of the two Decaturs, according to the Census of 1910, was 10,346, about one-third of which, or 3,401, were negroes, the great majority living in Decatur. The population of the two cities in 1900 was 7,551, showing a gradual and healthy growth since that time. Considered as one community for the purpose of this report, the Decaturs form the largest city in northern Alabama. Two railroads and river transportation furnish easy communication with other points in the State and beyond.

Water Supply.

The public water supply of the Decaturs is obtained from the Tennessee River and service is furnished by a private water company. In addition to river water a varying amount of "spring" water enters the pump well. Prior to 1910, the river water was distributed without any purification. In that year, rapid sand filters were installed and since then filtered water is supposed to have been furnished the consumers. From the data obtained, it is apparent that the public supply is being used by practically the entire population of both the Decaturs, the distribution system being approximately coincident with the built-up area.

About 2,000,000 gallons of water, which is about the capacity of the plant, are consumed daily. This allows the general average of 200 gallons daily per capita. A number of industries are supplied but the proportionate amount of water used by these could not be determined. A pressure-equalizing standpipe of 287,000 gallons capacity serves as the only reserve supply.

In case of fire and when taps are left open during cold weather to prevent freezing or are used extensively for lawn sprinkling, it has been impossible to maintain the service with filtered water. At such times it has been customary to pump raw, untreated river water directly to the service mains. No warning has been given upon these occasions, apparently because of the generally prevailing belief that the raw river water is safe at all times.

The filter plant is operated by a superintendent who, at the most, has only a general working knowledge of the essential principles of water purification, and who lacks the skill and training required for

efficient and intelligent control of filtration processes. There are no facilities at hand for determining the amounts of coagulant required to meet changing conditions of alkalinity and turbidity in the raw water and no means of checking the efficiency of the filters.

In the light of our present knowledge concerning the pollution of streams draining populated watersheds, the fact that purification of the Decatur supply has undoubtedly at all times been unreliable and on numerous occasions entirely dispensed with, justifies placing the supply under suspicion as to its sanitary quality.

There are a great many wells throughout the two cities, but it is believed that these are not used to any considerable extent for drinking purposes. They are sunk to varying depths in clay and "chirt" or partly disintegrated limestone. Because of the easy access of surface wash in many instances and because of the proximity to insanitary privies with the dangerous possibility of underground channels in the limestone, the majority of these wells should be placed under suspicion.

The deep well at the Louisville & Nashville Railroad shops deserves especial attention, as it is used regularly by about 1,800 employees for drinking purposes. This well is located within the grounds and is stated to be drilled 175 feet, the water rising into a roofed-in pump well from which it is distributed. An incinerating device for the disposal of human excrement is located within 100 feet of the well.

A small number of cisterns are in use, but those seen are of good construction and maintained in fair condition.

Milk Supply and Other Foodstuffs.

No specific data could be obtained as to the number of dairies and private cows, and no apparent local control or supervision is exercised over the production or handling of milk. The largest dairy handles milk shipped from Tennessee and is probably operated with average sanitary precautions. Several small farm dairies are located near by in the county. There are a large number of private cows supplying milk, usually to several families. None of the supply is pasteurized. Most of the milk delivered from the dairies is bottled.

Inspection of a number of the dairies revealed conditions demanding immediate attention. Suspicious water supplies, inadequate facilities for handling milk, dirty stables and cows, indicating no apparent knowledge of the dangers of infected milk, require remedial measures and supervision. Milk from private cows is also produced and handled in many instances without proper precautions as to cleanliness.

Practically all the ice cream consumed in the Decaturs is manufactured by the company who ship their milk in from Tennessee, a distance of about three hours' run. About 400 gallons of ice cream

is the daily output during the summer. Some of this is shipped to near-by towns.

Vegetables, eaten uncooked, are obtained from a number of sources, both local stores and private gardens. Oysters are said to be seal-shipped from Baltimore markets. There is apparently but little local supervision over the handling of foodstuffs, and perishable fruits and vegetables are frequently found exposed to dust, flies, and promiscuous handling.

Sewage Disposal.

The first public sewers were laid in 1889 and extensions have been made from time to time. At present it is estimated that only about 60 per cent of the population of both Decaturs have sewer connections to their houses. The system is of the combined type, receiving both storm water and sewage. The raw effluent is discharged directly into the Tennessee River through six outfalls placed usually below low water level. The uppermost outfall is located only about 500 feet below the waterworks intake, but probably at no time affects the quality of the water supply.

There are no public records giving any information concerning the number of houses connected to sewers. It was found that a considerable percentage of premises connected to sewers maintained outside closets, which, while offering some advantages over the usual type of surface privy, were found in many instances to be most insanitary, offering easy access to flies.

It is estimated that about 40 per cent of the population depend entirely upon surface privies. In the majority of these there is no receptacle whatever for excreta, which are deposited on the surface of the ground with no protection from flies, chickens or other domestic animals. There is apparently no systematic scavenging and many privies were found in a most despicable condition. They are widely scattered throughout both Decaturs, and their general insanitary construction and maintenance results in extensive soil pollution.

When these deplorable conditions were pointed out to the city officials and the dangers emphasized, steps were immediately taken to abate the more insanitary conditions found. A number of wretched privies and outside closets were thoroughly limed and boarded up by the mayor of Decatur.

Mention should also be made of the very unsatisfactory collection and disposal of garbage, rubbish, and stable manure. Many yards and alleys were found littered with filth of all description. Every opportunity is offered for the breeding of flies, and these pests are said to be very prevalent in summer.

PREVALENCE OF TYPHOID FEVER IN THE DECATURS.

Although communicable diseases are required to be reported by State law, no record exists of the number of cases of these diseases that have occurred. The only facts upon which could be based an estimate of the past prevalence of typhoid fever are the mortality records, preserved by the county health officer, and these are admitted to be incomplete returns, somewhat less than 90 per cent of all deaths being reported. It was noted that in many instances no cause of death was given.

These records showed 12 deaths from typhoid fever during the five years 1910–1914 in the two Decaturs, an average death rate of approximately 22 per 100,000. The total deaths for this period give a yearly average of 18 per 1,000. The average death rate from typhoid fever in the whole registration area during 1913 was 17.9 per 100,000, and the general death rate from all causes was 14.1 per 1,000. The reported death rates for the Decaturs, given above, are undoubtedly low when compared with the rates for other communities living under similar sanitary conditions and indicate incomplete records.

In 1914 only three deaths from typhoid fever were reported. These occurred in August. The deaths reported during the five years 1910–1914 were also returned during the summer and fall months. From these records it would seem that this disease had been most prevalent during those months.

In attempting to estimate the number of cases of typhoid fever that had occurred during 1914, a canvass of all the physicians disclosed a knowledge of about 30 cases, 10 of which were said to have occurred during March. From the observations made during the present investigation it seems very probable that cases of typhoid fever had been considered and often treated as malarial fever. In reply to questions as to the general prevalence of typhoid fever the usual answer was that there had been very few or no cases of the disease.

In the present outbreak, in addition to the 27 cases reported prior to February 14, the writer was able to establish positive diagnoses in 53 other cases, making a total of 80 cases. As will be seen by the chart, only 12 of these cases gave dates of onset later than February 14. It is evident, therefore, that 41 cases had remained unrecognized up to that time. This may be explained in part by the mildness of the disease, for which reason no medical attendance had seemed necessary. Prodromal symptoms were usually present, and the onset was often accompanied by chills and headache. Quinine had been administered in many instances with no apparent effect. In children the disease was generally mild. A low fever and absence of rose spots and abdominal symptoms made diagnosis rather difficult in some cases.

Widal Reactions.

In order to assist in establishing the diagnosis in the more doubtful cases, 77 specimens of blood were forwarded to the State laboratory and 63 positive Widal reactions were reported. The 14 cases giving negative reactions were not considered typhoid, clinically, and are not included in the present report. Two specimens gave positive reactions only with the paratyphosus B organism. Only one clinically typical case failed to give a positive Widal reaction.

Fatalities.[1]

There were but four deaths reported to March 23, giving a fatality rate of only 5 per cent. Two of the deaths were among the eight cases reported among the negro population, indicating the high fatality rate of 25 per cent for that race or very incomplete case reports.

EPIDEMIOLOGIC DATA.

Dates of Onset.

The chart shows graphically the estimated dates of onset in 79 of the 80 cases reported. The onset in one case was not definitely determined but occurred prior to February 20. The first case occurred December 31, and eight others were taken sick between January 1 and 19, at which time the rate of attack rather suddenly increased. Only four cases are reported after February 16, the last on March 1.

Period of Infection.

In estimating the probable date of infection in typhoid fever, it has been customary to accept about 14 days as the average period of incubation. That it may be considerably less than this is shown definitely by the report [2] of an outbreak in Hanford, Cal., in March, 1914. With a definite date of infection established, it was found that the onset in over half of the cases occurred in the first seven days following the dinner and that over two-thirds of the cases developed by the tenth day. The shortest period of incubation was 3 days and the longest 29 days.

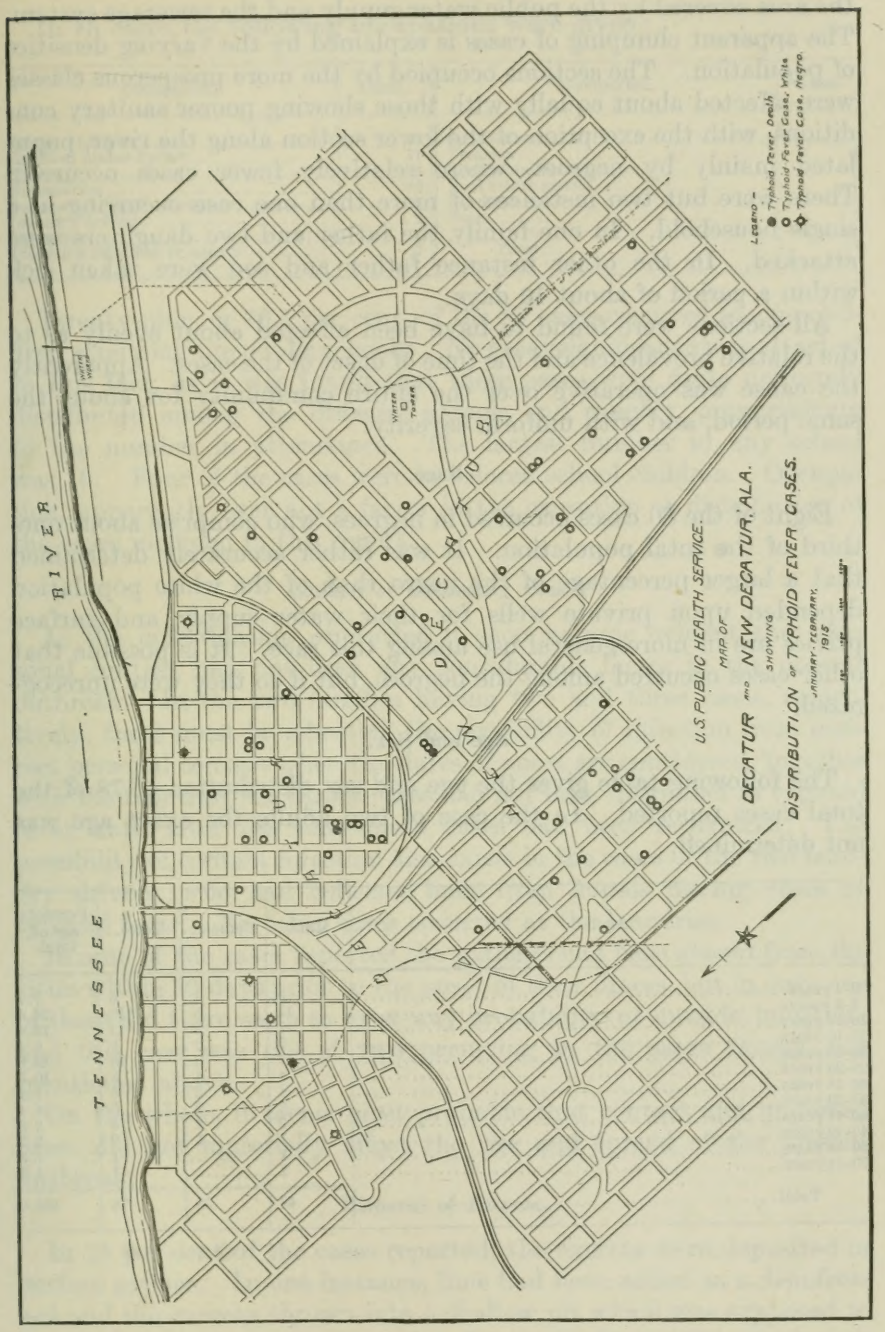
In the present outbreak it is apparent that the causation period began about December 15 to 25, and extended to February 5 or later.

Geographic Distribution of Cases.

The accompanying map shows the very uniform distribution of cases throughout the two Decaturs. The heavy broken line indicates

[1] The writer, in passing through Decatur in the latter part of April, 1915, ascertained that since this report was submitted there have been 2 other deaths among the 80 cases investigated. This raises the fatality rate to 7.4 per cent.

[2] Sawyer, W. A., Ninety-three persons infected by a typhoid carrier at a private dinner. J. A. M. A., Oct. 31, 1914. LXIII, No. 18, p. 1537.


U.S. PUBLIC HEALTH SERVICE.
MAP OF
DECATUR and NEW DECATUR, ALA.
SHOWING
DISTRIBUTION of TYPHOID FEVER CASES.
JANUARY-FEBRUARY,
1915
Legend –
Typhoid Fever Death
Typhoid Fever Case, White
Typhoid Fever Case, Negro.
TENNESSEE
RIVER
DECATUR
MAIN
WATER TOWER

roughly the limits of the populated areas. This corresponds also to the area covered by the public water supply and the sewerage system. The apparent clumping of cases is explained by the varying densities of population. The sections occupied by the more prosperous classes were affected about equally with those showing poorer sanitary conditions, with the exception of the lower section along the river, populated mainly by negroes, where relatively fewer cases occurred. There were but two instances of more than one case occurring in a single household. In one family the father and two daughters were attacked. In the other instance father and son were taken sick within a period of about 10 days.

All sections were found to have been affected about evenly as to the relative prevalence and the time of onset of the cases. Apparently the cause was operative over the entire community for about the same period, and with uniform severity.

Race.

Eight of the 80 cases occurred in negroes, who comprise about one-third of the total population. It was rather accurately determined that a larger percentage of the negro than of the white population depended upon private wells for their water supply, and surface privies are in more general use among this race. It is possible that other cases occurred among the negroes, but if so they were unrecognized.

Age and Sex.

The following table gives the age and sex distribution of 78 of the total cases reported. In the case of two adults the exact age was not determined.

Age.	Male.	Female.	Total.	Percentage of total.
0–4 years	5	1	6	7.7
5–9 years	11	8	19	24.4
10–14 years	7	5	12	15.4
15–19 years	2	3	5	6.4
20–24 years	7	3	10	12.8
25–29 years	4	4	8	10.3
30–34 years	4	2	6	7.7
35–39 years	3	2	5	6.4
40–44 years	2	1	3	3.8
45–49 years	1	1	2	2.5
50–54 years	1	.....	1	1.3
70–74 years	1	.....	1	1.3
Total	48	30	78	100.0

Occupations.

In 78 cases the following occupations were given:

Occupation.	Cases.	Occupation.	Cases.
School children	29	Contractors	2
Children under 5 years	11	Preacher	1
Clerks	6	Livery stableman	1
Housewives	10	Real estate agent	1
Laborers, L. & N. shops	6	Huckster	1
Laundry drivers	2	None	3
Laborers	3		
Traveling salesmen or agents	2	Total	78

Twenty-nine, or 36.5 per cent, of the 80 cases occurred among children attending the public schools. No great significance was attached to this fact, as it was found that these cases were quite uniformly distributed among the different schools and roughly proportionate to the number in attendance. The largest number in any school was 10. Four of the cases were in colored school children. Occupation, apparently, was not a factor in the causation or distribution of the cases included in this report.

Contact or Secondary Cases.

As the investigation proceeded it soon became evident that personal contact had not been any considerable factor in the present outbreak. In the two families having two and three cases, respectively, there must be admitted the possibility of infection from indirect personal contact when the dates of onset are considered, together with the fact that the earlier cases had not been diagnosed as typhoid fever until after the subsequent cases had been recognized. The possibility of contact infection also exists in the cases of the two laundry drivers, who had collected linen from houses having cases of typhoid fever. No other cases occurred at the laundries.

In nine of the cases reported the patients had been absent from the cities within 30 days prior to the onset of their illness, but in only one of these did there seem to exist any probability of outside infection, and this case was one of two occurring in the same family and mentioned above.

On the whole, it seems most probable that contact and imported cases did not materially affect the rise and spread of the present outbreak.

Disposal of Excreta.

In 25 per cent of the cases reported, the excreta were deposited in surface privies. In one instance, lime had been added as a disinfectant and the excreta thrown into a shallow pit which was supposed to be filled in with earth after each lot was added. The discharges from 15 of the cases were thrown into outside water-closets. In the

remainder of the cases, inside flush closets served for the final disposal of the discharges.

The efficiency of the control of typhoid-fever cases is determined primarily by the efficiency of the disinfection of infectious material leaving the bedsides of the patient. With absence of, or with incomplete disinfection, and especially with unrecognized typhoid cases present, the opportunities for the spread of infection by contact would be determined in a large measure by the methods in use for the ultimate disposal of sewage. In the Decaturs this problem of sewage disposal deserves immediate consideration and remedial measures for the abatement of insanitary privies.

Relation to the Milk Supply.

Practically none of the patients reported were extensive milk drinkers. Several stated that they could not afford sweet milk; 29 used no milk at all or only in cooked foods; 23 gave histories of drinking only buttermilk. One family had used only canned milk. The remaining 27 cases had drunk raw fresh milk, although not extensively, and had used milk on cereals or in hot drinks to some extent. The milk used by 48 of the families affected by the outbreak was obtained from entirely different sources, in most instances from private cows. In 31 cases, two or more of the families had purchased milk from nine dealers, only two of whom had more than five cases among their customers.

No evidence was found pointing to ice cream, oysters, or other foodstuffs as possible factors in the outbreak.

General Sanitary Conditions.

Although a fair percentage of the houses and premises were found clean and well kept, the general sanitary rating of the community as a whole would be necessarily below the desirable average for a prosperous and progressive American community. The sanitary rating of the Decaturs is low because of extremely insanitary privies with an incomplete public sewerage system, a large number of private wells exposed to the dangers of surface washings and seepage from privies, and inadequate disposal of garbage, stable manure, and other offensive wastes.

Yet, in the present outbreak, general sanitary conditions appear to have exerted no appreciable influence upon the incidence of the disease or its spread. This was undoubtedly due largely to the season of occurrence and the absence of flies and effective personal contact.

Relation of Cases to Water Supply.

The various possible factors so far considered seem to be eliminated as probable causative agents in the present outbreak.

The season of occurrence, the rather explosive character of the outbreak, the uniform and wide distribution of the cases reported and the elimination of other possible causes point strongly to the public water supply as the most probable cause of the outbreak.

Sixty-three, or nearly 79 per cent of the cases reported, gave histories of having used the city water supply to the exclusion of all other sources of supply during the 30 days prior to the onset of illness; 16 patients had used the public supply principally but had occasionally drunk water from wells or other sources. One patient used a private-well supply and admitted using no city water. Therefore, all but one case had used the public water supply wholly or principally.

From all evidence thus far set forth it is apparent that the public water supply was the only factor common to all, or practically all, of the 80 cases. The defendants of the public water supply made the suggestion, so often heard, that if the water supply had been at fault there would have been necessarily a much higher percentage of cases among the consumers. There were undoubtedly more than 80 cases affected during this outbreak, but in all outbreaks due to polluted water supplies the percentage of the population affected depends largely upon the degree of the pollution and perhaps to some extent upon individual susceptibility. It is usually recognized that not all persons exposed to infection by diphtheria or scarlet fever contract the disease.

The distribution of the 80 cases in the Decaturs corresponds practically to the area supplied by the private water company. That the public water supply was the principal factor concerned in the causation of the outbreak the following description of the operation of the plant leaves but little doubt:

PUBLIC WATER SUPPLY.

The two Decaturs are supplied by water taken from the Tennessee River. The service is furnished by a private water company. In judging the sanitary quality of a water supply, first consideration should perhaps be given to the source of the supply.

The Tennessee Watershed.

The total drainage area of the Tennessee watershed above the Decaturs comprises approximately 26,700 square miles, with a total population, estimated July 1, 1914, of 1,320,617, or an average distribution of 49 per square mile. Of this total, 1,133,599, or about 86 per cent, is rural and 187,018 is urban, including incorporated

places of 2,500 or over in 1910. There is no community of 2,500 population or over located directly on the river below Chattanooga, Tenn., a distance of 149 miles above Decatur. The only city of any size situated on the tributaries within this distance is Huntsville, Ala., with a population of 7,611 in 1910, about 32 miles by water from Decatur.

The counties within the State of Alabama and contributing drainage to the Tennessee River within 100 miles of Decatur have a combined population of about 169,000, 90 per cent of which is rural. The principal drainage, therefore, entering the river within 100 miles of Decatur is from rural districts. Huntsville is the only city of considerable size discharging raw sewage directly into the river or its tributaries within this area.

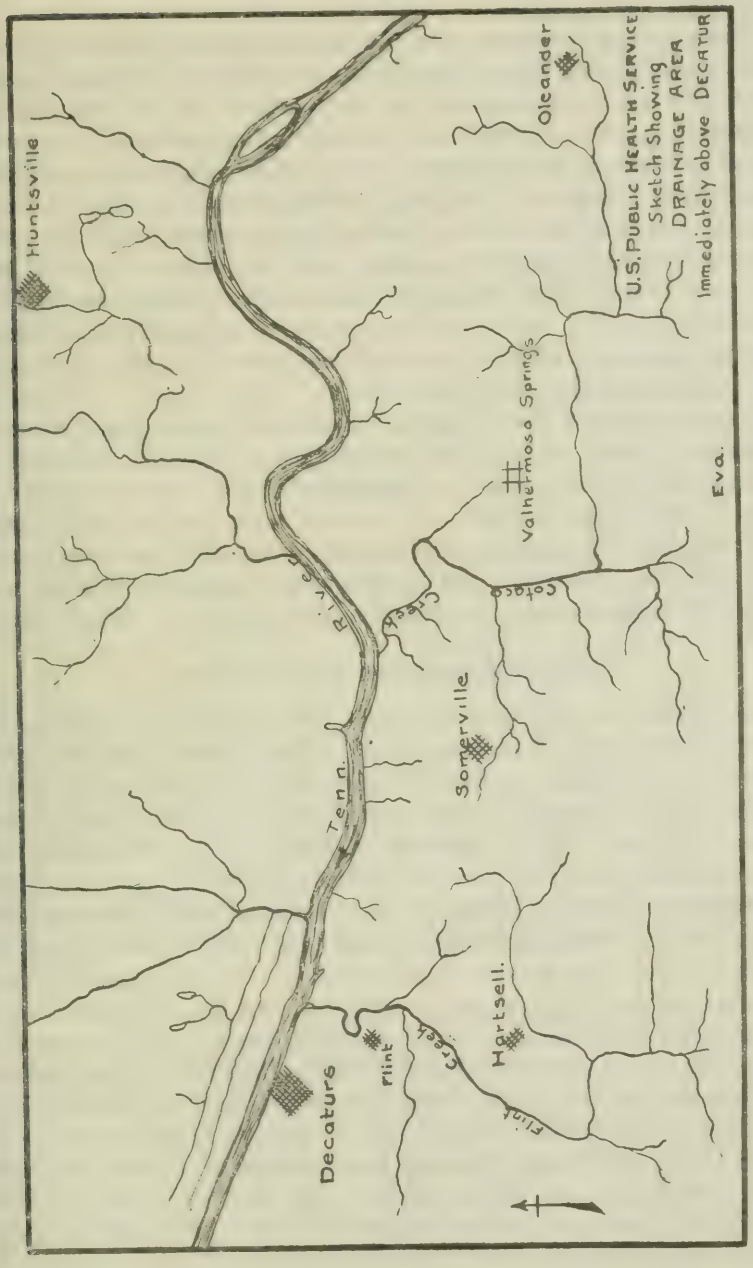
The pollution of the Tennessee River at Decatur is undoubtedly subject to considerable fluctuations and is greatest following heavy rains.

Typhoid Fever on the Watershed.

In collecting evidence pointing to a water supply as responsible for typhoid fever outbreaks it is not always possible nor is it necessary to be able to trace the infection to a definite or specific source. To establish the prevalence of the disease within reasonable distance above the intake of a supply and to show ready means for conveyance of infection from the original sources to that supply is proof sufficiently convincing, though perhaps only circumstantial.

Rather authentic reports disclosed the fact that typhoid fever had been prevalent in the vicinity of Valhermoso and Eva, both of which drain into Cotaco Creek, emptying into the Tennessee about 15 miles above the Decatur intake. The first case is reported to have occurred in June, 1914, near a small creek a short distance above Cotaco Creek. More than 30 cases are reported to have followed, and the disease was said to be prevalent in that area as late as January, 1915. The rural population affected by this local outbreak depend upon surface privies, and it can not be expected that perfect disinfection of the infectious discharges was accomplished, at least not in all instances. The accompanying sketch shows the relation of the area affected by this outbreak to the Decatur intake.

In searching for further evidence of typhoid fever on the immediate watershed, it was found that in 1914, among the 169,000 people living on the watershed within the boundaries of the State, 71 deaths from this disease were reported to the State board of health, giving a minimum yearly death rate of 40 per 100,000. Madison County alone reported 20 deaths in 1914, or a death rate of about 65 per 100,000. The State laboratory reports six positive Widal reactions


U.S. Public Health Service
Sketch Showing
DRAINAGE AREA
Immediately above Decatur
Huntsville
Oleander
Valhermosa Springs
Eva.
Somerville
Hartsell.
Decatur
Flint
Tenn. River
Cotaco Creek
Flint Creek

from blood specimens received from Huntsville, five in July and one in December. It is evident, therefore, that the urban population contributed to the generally high rate of 1914.

This section of the State has not been admitted to the registration area of the United States Census Bureau and the mortality returns are known to be incomplete. So far as could be determined, cases of communicable diseases are generally not reported, so that the actual prevalence of the disease under discussion can not be determined with accuracy. Accepting a fatality rate of from 7 to 10 per cent, it is seen that there undoubtedly occurred over this part of the watershed during 1914, not less than 700 cases of typhoid fever, probably more. These cases were distributed largely among a rural population, and it would be reasonable to suppose that infectious excreta from some of the cases would at some time find its way into the river, especially after heavy rains.

It seems certain that no great amount of raw sewage enters the Tennessee River within 100 miles above Decatur, although extremely dangerous pollution undoubtedly does reach the river at times of excessive rainfall. No stream once polluted with human sewage is safe for use as a drinking supply until it has been purified. It is believed, however, that a properly managed filtration plant at the Decaturs would be capable of producing a supply safe at all times.

THE NEW DECATUR WATER WORKS.

The present supply system dates from 1889 when pumps were installed to furnish raw river water. The present plant is located near the upper limits of New Decatur and supplies both of the Decaturs. In 1910, rapid sand filtration was begun with two Roberts filters supplying about 1,000,000 gallons daily. Two filter units have since been added. These were installed by the American Water Softening Co. and the present yield has averaged 2,000,000 gallons daily. No detailed description of the plant will be attempted, only the more vital defects being touched upon. The pump well, in addition to receiving river water by gravity from an intake located 300 feet from shore in the deep channel, is fed also by spring water which was encountered in excavating the well. Nothing definite is known of the source of the spring water except that it comes from the surrounding limestone formation and is admitted to the pump well through two 4-inch pipes through an outer well which collects groundwater seepage. Its volume varies with the river stage. Public opinion has condemned this spring water, but there seems no definite reason for assuming that it is more highly polluted than the raw river water.

Alum is added in the suction line leading from the pump well to two elevated wooden coagulating tanks, having a combined capacity

of about 160,000 gallons. The water flows by gravity from the coagulation tanks to the four sand filters. These are circular wooden tanks with a combined filtering area of 704 square feet. With the average daily yield of 2,000,000 gallons, filtration takes place at an average rate of about 125,000,000 gallons per acre per 24 hours. This rate, while not excessive for rapid sand filtration, assumes a satisfactory coagulation and settling before the water is applied to the filters. From the filters the water falls into a clear-water well of about 36,000 gallons capacity, less than one-half hour's supply. From this clear well it is pumped directly to the service mains, to which at one point has been joined a 287,000-gallon pressure-equalizing standpipe, maintaining a general pressure of about 50 pounds through the two cities.

Two high service pumps are installed for fire purposes or other emergencies. These pumps can draw only from the raw-water pump well and therefore when they are in use, filtration is abandoned and raw water is pumped directly to the mains. It is also necessary at such times to cut off the standpipe in order to provide sufficient pressure for fires.

In addition to the above equipment, there was installed, February 14, 1915, a temporary apparatus for the addition of hypochlorite of lime to the filtered water. A barrel was provided for mixing the hypochlorite with water. Four pounds of hypochlorite of lime were added every 12 hours and the barrel was filled with water. From near the bottom of the barrel the solution was piped into the clear-water well and discharged upward into the open inverted elbow of the suction line leading to the pump. A rough gauge in the barrel and a shut-off cock in the discharging pipe were the only means of control of the rate at which the solution was being introduced. Although a definite quantity of the solution could be added within a given period, it would be practically impossible to regulate the rate of flow so as to secure a uniform concentration of the disinfectant in the treated water.

Defects in Operation of the Plant.

The process of rapid sand or mechanical filtration such as is in use at the Decaturs, depends upon the filtration of water through sand at a rapid rate, compared to the rate in slow sand filtration, after proper coagulation and sedimentation. This process of rapid sand filtration is especially applicable to turbid waters, and efficiency depends largely upon the preliminary coagulation and sedimentation, removing the bulk of the suspended matter. Otherwise it resolves itself into a rapid process of straining through sand and relatively little turbidity and few bacteria are removed.

In the construction and operation of the plant at New Decatur, a number of defects deserve severe criticism and condemnation. The following points demand immediate attention and action:

A. Defects in mechanical construction:
   1. Insufficient provision for coagulation and sedimentation.
   2. Insufficient capacity of clear-water reservoir.
   3. Lack of proper apparatus for addition of disinfectant.

B. Defects in operation and supervision:
   1. Lack of competent filter operator.
   2. Addition of alum by guesswork.
   3. No provision for determining the safety of the filter water.
   4. Frequent use of raw untreated water.
   5. Extravagant waste of filtered water.

Defects in Mechanical Construction.

These are essentially engineering problems, but the necessity for certain changes in the mechanical equipment will be briefly discussed.

With the present average daily output of 2,000,000 gallons, the two settling tanks of a combined capacity of 160,000 gallons permit of about two hours' storage for sedimentation after the addition of coagulant. This length of storage could hardly be considered sufficient to effect the degree of sedimentation and clarification usually necessary. After the addition of coagulant, a longer period of sedimentation will undoubtedly be necessary in order to relieve the filters of considerable burden and at the same time increase their yield. Frequent determinations are necessary in order to ascertain the quantity of coagulant and the period of sedimentation necessary to meet the constantly changing conditions in the river.

The present clear-water reservoir of a capacity of about 36,000 gallons provides less than a half hour's reserve supply of filtered water. In order to obtain sufficient pressure for fire service it has always been necessary to pump unfiltered water from the pump well directly to the mains, a procedure which deserves severest condemnation. The immediate construction of a filtered water reservoir[1] of a size to provide at all times sufficient reserve supply for fires and other emergencies is imperative. The writer was advised that steps have been taken for the construction of such a reservoir to have a capacity of about 500,000 gallons, which will probably meet ordinary demands.

The temporary apparatus installed for the addition of hypochlorite of lime is only a makeshift and should be replaced by some modern equipment which will permit of definite control. At times of extreme pollution the burden imposed upon the filters might easily lessen their efficiency and require the addition of a disinfectant.

[1] In the latter part of April, 1915, on visiting Decatur the writer found that the water company had installed a filtered water reservoir with a capacity of 1,000,000 gallons. This reservoir is located adjoining the pump house, and with this reserve supply of filtered water it is hoped to be able to avoid using raw river water for fires or other emergencies. No provisions, however, had been made for any definite control over the efficiency of filtration.

Defects in Operation and Supervision.

The operation of the filter plant at New Decatur is in charge of a superintendent who admits frankly that he lacks the necessary training and equipment for determining the condition of the raw water and the required amount of coagulant to be added. He is also lacking in the proper training and equipment necessary to determine the sanitary quality of the water supplied to consumers. The quantity of coagulant required depends upon the turbidity and alkalinity of the raw water, and it is impossible to determine these factors by mere inspection. The sanitary quality of the filtered water can be determined only by intelligent interpretations of bacteriological examinations.

During 1914 no coagulant was added during May and June. Alum was added during the remaining 10 months at the daily average rate of 40 pounds per 1,000,000 gallons, or slightly less than 0.3 grain per gallon. No definite statement can be made as to the quantity of alum that should have been added during this period, as there are no available records giving alkalinity and turbidity readings, but with a plant operated under the conditions existing at Decatur a coagulant would undoubtedly be necessary at all times. The amount of alum added during 1914 should generally be considered insufficient when treating water of a character similar to that of the Tennessee River.

The introduction of raw untreated river water directly to the mains at any time is most reprehensible and deserves severe condemnation. This practice was defended by the superintendent with the statement that the river water had been assumed to be safe. No warning had ever been given, so far as could be learned, to the health authorities when it was necessary to use raw water, and hence no precautions could have been taken by the consumers.

RESULTS OF BACTERIOLOGICAL EXAMINATIONS.

Bacteriological examinations of a water supply offer valuable corroborative evidence in support of findings of a general survey of the source of the supply, the operations of purification, and the effect of the supply upon the community. The determination of the presence and relative percentage of that group of intestinal organisms known as the "colon group" has been accepted as the index of sewage pollution. The isolation of the typhoid organism from a polluted water supply is most difficult and often impossible. Since its natural habitat is the human intestine, it is not unreasonable to expect its presence at some time or other in a stream polluted by human excrement.

Various standards have been presented for rating the purity of water supplies, although the amount of permissible pollution undoubtedly varies under different conditions. *B. coli* should practi-

cally never be found in 1 c. c. of filtered water and only occasionally in 10 c. c. amounts. The presence of over 100 bacteria of all forms per cubic centimeter is usually sufficient to arouse suspicion.

Examinations Prior to February 17, 1915.

No regular bacteriological examinations have been made. The following table gives the results of such examinations as had been made prior to February 17, 1915:

Date.	Source.	By whom examined.	Total bacteria per c. c.[1]	*B. coli* present.[2]			*B. coli* estimated per 100 c. c.
				10 c. c.	1 c. c.	0.1 c. c.	
1913. Dec. 30..	City tap.	St. B of H. for L. & N. R. R.	About 400.....	.....	.....	.....	None in 10 c. c.
1914. Aug. 8...	...do.....	St. B. of H. for So. Ry.	About 500.....	(3)	(3)	(3)	Small numbers.
1915. Jan. 9...	...do.....	E. M. Duncan for L. & N. R. R.	Certified as safe for common carriers.	.....	.....	.....	
Jan. 28..	...do.....	St. B. of H.....	Not given.....	.....	.....	.....	"Large numbers."
Feb. 9...	...do.....	St. B. of H. for Dr. Watson.	About 300.....	.....	.....	.....	Do.
Feb. 12..	...do.....	W. H. Beers for Water Co.	80.....	.....	.....	.....	40.*
Feb. 13..	...do.....	E. M. Duncan for Water Co.	382.....	.....	.....	.....	166.
Feb. 14..	Tap at pump house.	St. B. of H.....	About 200.....	.....	.....	.....	100.
Feb. 17..	City tap.	.....do.....	20.....	.....	.....	.....	None in 10 c. c.

[1] Standard agar.
[2] Lactose bouillon except (*), presumptive test in lactose bile.
[3] Small numbers.

From the above table it is clear that no very favorable results had been reported prior to February 17, 1915. On January 9, 1915, the supply was certified as safe for use on common carriers, although the data set forth in this report includes this date within the period of causation of the outbreak. From all the evidence at hand it would seem doubtful if the water supply had been safe for any length of time during the past several months at least.

Following the unfavorable report of August 8, 1914, the Southern Railroad Co. had discontinued the use of this water supply and yet no action was taken to improve the quality of the supply.

Examinations Made, February 17–26, 1915.

The writer installed a temporary laboratory in a room provided by the mayor of Decatur and from February 17 to 26 daily bacteriological examinations were made of samples of water before and after purification in order to check the results given in the above table and to determine the efficiency of the purification plant.

The following table gives the results of 55 examinations in the service laboratory:

Bacteriological examinations of the Decatur water supply February 17–26, 1915.

Date.	Source.	Number of samples.	Total bacteria per c. c. agar,[1] 37° C.	Percentage times *B. coli* present in amounts designated.[2]				Number of *B. coli* estimated per 100 c. c.
				10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.	
1915.								
Feb. 18.....	River above intake....	3	342	.....	100	66	33	4,000
Feb. 17–25..	Pump well.....	8	126	.....	63	13	.....	176
Feb. 17–25..	Spring in pump well..	8	53	.....	75	50	.....	525
Feb. 17–25..	Water applied to filters	8	118	.....	87	50	.....	538
Feb. 17–25..	Filtered water well....	8	15	87	13	.....	.....	20
Feb. 17–26..	City taps.....	12	17	82	18	.....	.....	23
Feb. 20–23..	L. & N. well.....	4	18	.....	100	25	.....	325
Feb. 17–26..	Private wells (4).....	4	93	100	75	25	.....	302

[1] Total count on standard agar-agar at end of 24 hours at 37° C.
[2] Gas formation in lactose bouillon confirmed by appearance of Endo plates.

The above results were obtained during a period when the filter plant was being operated apparently above its average efficiency, with a very low turbidity in the river and a pollution surely not excessive. During this period the filtration had succeeded in removing only about 87 per cent of the total bacteria and about 96 per cent of the *B. coli* present in the raw water. If this should prove to be the maximum efficiency obtainable, it would be impossible to guarantee a safe effluent the greater part of the time.

Although hypochlorite of lime has been added to the filtered water since February 14 there was no appreciable effect of this disinfection shown by bacteriological examination.

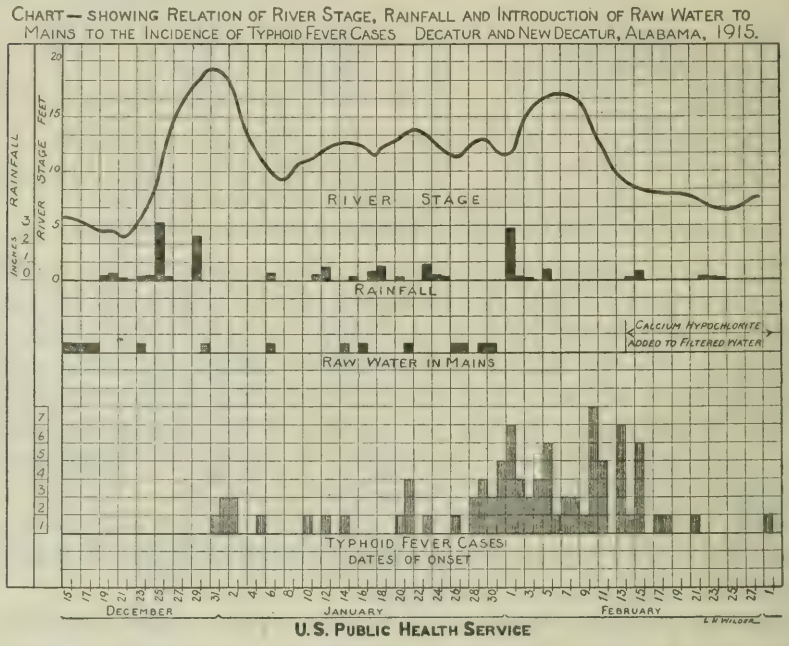
The bacteriological findings for the period February 17 to 26 indicate quite definitely that the purification obtained was quite unreliable, and that the filtered water showed evidence of pollution beyond the limits of safety.

Although it is believed that water from private wells played no effective rôle in the present outbreak, attention is called to the results of the examinations made of a small number of wells. The deep well at the Louisville & Nashville shops is used regularly by about 1,800 employees and the purity of this supply deserves further consideration. It seems evident from a limited examination that the extensive soil pollution from numerous insanitary privies is affecting the sanitary quality of private wells.

RELATION OF WATER SUPPLY TO THE TYPHOID OUTBREAK.

Sufficient evidence has undoubtedly been presented to warrant the statement that the public water supply should be held directly responsible for the recent outbreak of typhoid fever in the two Decaturs. Typhoid fever was excessively prevalent over the water-

shed above Decatur during 1914 and early in 1915. The accompanying chart shows the occurrence of heavy rains on December 25, about one week before the onset of the first case of typhoid fever that occured during the outbreak. It is entirely probable that these rains washed into the river infectious material which was carried to the Decatur intake in sufficient amount to cause the outbreak. The accompanying sketch shows the relation of the cases



about Valhermoso and Eva to the Decatur intake. The chart also indicates the days upon which raw river water had been admitted directly to the mains from December 15 to January 30. It is also apparent that the filter plant has not been operated at an efficiency such as to guarantee the safety of the supply.

From the above statements the chain of evidence seems rather convincing when considered with the fact that the only factor in common among 79 of the 80 cases reported was the use of this water supply and that other factors have been eliminated.

PROPHYLACTIC MEASURES TAKEN.

In addition to the boiling of drinking water following the recommendations of the local authorities, on February 11, prophylactic immunization with antityphoid vaccine was apparently encouraged by the majority of local physicians. It is estimated that probably about 2,000 persons were given prophylactic vaccine and no severe

reactions were attributed to its use except in two cases which were apparently incubating typhoid fever at the time the vaccine was given.

SUMMARY AND CONCLUSIONS.

Typhoid fever was prevalent in the two Decaturs in epidemic form during January and February, 1915. A definite outbreak occurred, the first case being reported December 31, 1914. Eighty cases were reported and definitely diagnosed between that date and March 1. Other unrecognized cases are believed to have occurred.

Milk, foodstuffs, contact, flies, and other common causes were shown not to have been responsible for the outbreak. The public water supply was the only factor in common to 79 of the 80 cases reported.

Typhoid fever was extremely prevalent on the Tennessee watershed a short distance above Decatur. Surface privies permitted extensive soil pollution. Heavy rains on December 25 can easily be conceived to have washed into the river and conveyed to the Decatur intake sufficient infectious material to cause the outbreak.

A survey of the construction and actual operation of the Decatur filter plant, supported by the results of the bacteriological examinations of the filtered water made during a period of careful operation of the plant, warrants the statement that at no time could the filter plant have been relied upon to furnish a pure and hence safe supply.

In addition to the influence of serious defects in the construction and operation of the purification plant, the sanitary quality of the Decatur water supply was further affected by the practice of introducing raw untreated river water to the service mains at frequent intervals. With undoubtedly dangerous pollution entering the river above, the people of the Decaturs were thus exposed to infection and the outbreak was the logical consequence.

Bacteriological examination on August 8, 1914, showed evidence of pollution at that time, but no steps were taken by the water company, the health authorities, or the citizens of the two Decaturs, to improve the quality of the water supply. Although the outbreak started December 31, no action was taken by the local authorities until February 11, when the boiling of all drinking water was advised.

The Tennessee River is not considered safe as a source for public water supplies unless the water is purified. The rather common idea that running water purifies itself is true to the extent that processes of natural purification do tend continually to reduce the pollution of a stream. However, recognized authorities to-day are quite unanimous in concluding that no stream receiving any considerable amount of human sewage is safe for drinking purposes until it has been subjected to artificial purification.

Although the reporting of communicable diseases is required by State health laws, it is not enforced, and there are no records to show that these diseases have ever been reported to the local health authorities in Decatur. With prompt and complete registration of all cases of sickness, the local health officers would have been forewarned and forearmed, able to recognize the unusual prevalence of typhoid fever and to take immediate steps to prevent its spread. With an efficient health organization, properly supported financially and receiving the full cooperation of the local physicians, considerable suffering and actual monetary loss could have been prevented.

RECOMMENDATIONS.

I. Improvement of Water Supply.

(1) Provision for competent, trained, filter operator who shall be capable of properly controlling the various processes of purification and of determining the purity and safety of the final effluent.

The value of skilled supervision and control is especially emphasized on account of the mechanical defects in the filter plant. With carefully controlled operation and the judicious use of disinfectants, it is reasonable to suppose that a safe water could be provided.

(2) Necessary structural improvements of the filter plant to provide for proper addition of coagulant; increased storage for sedimentation following the addition of coagulant; sufficient storage capacity for filtered water; efficient disinfection by hypochlorite of lime or liquid chlorine when necessary.

Hypochlorite of lime, when properly used in small amounts for the disinfection of filtered water, is decomposed and is not perceptible to the taste or smell.

(3) Discontinuance of the practice of introducing raw, untreated water directly to the mains. If this becomes necessary at any time, the local health authorities should previously be notified in order that proper measures of safety may be instituted. Definite protection for the consumer could be more surely guaranteed if a written or verbal permission from the health officer was required before raw water was turned into the mains.

(4) Provisions to enable the local health authorities to obtain regular bacteriological examinations of the filtered water. Daily records of examinations are preferable, but samples should be examined at least once each week.

Particular attention is called to the importance of bacteriological examinations of water supplies, as they offer the only reliable and delicate proof of the sanitary quality and safety of the water.

(5) The abandonment of all private wells that show evidence of pollution from dangerous and insanitary privies.

Special attention should be given to the well supply used by the employees of the Louisville & Nashville Railroad shops. Dangerous infection of this well would mean the exposure of a large number of employees.

II. Development of Efficient Local Sanitary Administration.

(1) *Passage of local ordinances for:*

(*a*) Prompt and complete reporting of every case of communicable disease to the proper health authority.

(*b*) Abolition of all insanitary privies and outside water closets.

(*c*) Rigid supervision and control of the construction and maintenance of sanitary privies in sections not reached by the public sewerage system.

(*d*) Proper disposal of night soil.

(*e*) Extension of sewerage system to reach all sections of the two cities.

(*f*) Enforcement of connections with public sewers wherever they exist.

(*g*) Efficient plumbing inspections.

(*h*) Enforcement and supervision by local health authorities of rigid disinfection and necessary precautionary measures at the bedsides of all persons having or suspected of having typhoid fever.

(*i*) Proper disposal of garbage, manure, and other wastes.

(*j*) Rigid supervision and control over the production and distribution of milk and the handling of foodstuffs in general.

The prompt reporting of all cases of communicable diseases is first in importance, because without a knowledge of the existence and prevalence of disease the health officer is unable to plan his campaign for the protection of his community.

The ordinances enumerated above may be in part specific ordinances and partly board of health regulations, having the authority of law. Only a brief outline of the more immediate needs has been attempted.

The vital importance of proper sewage disposal is emphasized. *Human excrement should be kept off the ground* and it should be so protected until finally disposed of that it could in no way be carried to foods and drinks.

In the spread of typhoid fever, special attention should be given to bedside prophylaxis. This should always be supervised by the local health authorities who should require in all actual or suspected cases efficient disinfection of all discharges, as well as general precautionary measures.

The production and handling of milk is at present in a deplorable condition and demands immediate measures for improvement. Milk is an ideal culture medium for the growth of bacteria and many

epidemics of typhoid fever as well as some of the other infectious diseases have been directly traced to the use of impure milk. The importance of pure milk in the feeding of infants is recognized.

(2) *Development of an efficient public health organization for the enforcement of sanitary ordinances.*—The importance and value of the "full time health officer" is being more fully recognized. A community of 10,000 people needs a health officer who can devote his full time to the various duties of that office, not a busy practicing physician who receives perhaps a small pittance for accepting the honorary title and rôle of guardian of the public health. This office requires a man trained in the principles of public hygiene.

For the Decaturs and for Morgan County as a whole, the cooperative plan of public health administration is to be recommended, a plan similar to that recommended by Phelps for certain small towns in Massachusetts.[1]

The problem of local administration for the protection of the public health finally resolves itself into a problem of finance, but no expenditures can be made from a municipal treasury that will bring better returns, dollar for dollar, than money expended for a well-organized and well-equipped health department. Instead of much sickness and suffering, it brings freedom from disease and the fear of epidemics. For less than 50 cents per capita the citizens of the two Decaturs could provide $5,000 yearly for the maintenance of an efficient health organization, surely an inexpensive health insurance. Something over $2,500 is now being paid out by the two Decaturs each year, with no real returns.

Under the cooperative plan, it would be recommended that the county should contribute its proportionate share, and that the Decaturs add to this a sufficient sum to provide at least $5,000 yearly. Instead of one county and two city health officers, there should be one full-time health officer, with headquarters in one of the Decaturs. The cooperative plan is believed to offer the best solution of the present problem and not to be in conflict with any provisions of the State health laws.

It is further recommended that the local police be utilized as sanitary inspectors, performing such functions as the health officer may recommend.

The necessity of a public health laboratory is also urgently recommended. With a small expenditure such a laboratory could be equipped for frequent examinations of the water and milk supplies and for diagnostic purposes. The health officer, with proper training, might easily perform such laboratory work as should be necessary.

[1] E. B. Phelps, Cooperative Public Health Administration. An Experiment in Small Communities. Reprint No. 222, from Public Health Reports, Sept. 25, 1914. Government Printing Office, Washington, D. C.

Even with a safe water supply, southern cities generally have a typhoid fever death rate of from 25 to 50 per 100,000 population, depending largely upon the general sanitary conditions prevailing.

Finally, it should be remembered that it requires the willing and hearty cooperation of the public at large to establish and successfully maintain an efficient public health administration, and special effort should be directed toward arousing and keeping alive a perpetual public enthusiasm.

ACKNOWLEDGMENTS.

It is desired here to express sincere appreciation of the many courtesies shown the writer during his investigation, by the local, county, and State health authorities, and by many physicians and others who manifested especial interest in matters pertaining to public health.

Much of the success of the investigation is due to Hon. James A. Nelson, mayor of Decatur, in providing a suitable laboratory room, invaluable laboratory assistants, and transportation, and in making many personal suggestions.

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